POULTRY trading network AND Diffusion of newcastle disease in THE Lake Alaotra region, Madagascar: a social network analysis

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Context

- Poultry sector
  - 34.4 millions (Faostat,2008)
    - Chickens, geese, ducks, turkeys
  - Smallholder production system
    - 2/3 rural population
  - Trading network
    - Renewal, sale, flows between different areas
    - Farmers, middlemen, live-birds markets, consumers (no slaughterhouse)
    - No regulation

- Importance in disease transmission (Vizcaíno et al, 2010,…)

Context

- Avian diseases
  - Newcastle disease
    - Affects wild and domestic birds
    - In Madagascar: first reported in 1946, 44% of mortality in 1999
  - Other avian diseases
    - Serological study
      - Fowl cholera : 71% (*n=187*) of chickens and 25% (*n=140*) of palmipeds.
      - Avian influenza: 15% (*n*=204) of chickens and 3% (*n*=175) of palmipeds

➔ Priority diseases (National veterinary services)

➔ Confounded in field because of similarities in clinical signs and epidemiology

➔ Unknown relative importance

Hypothesis

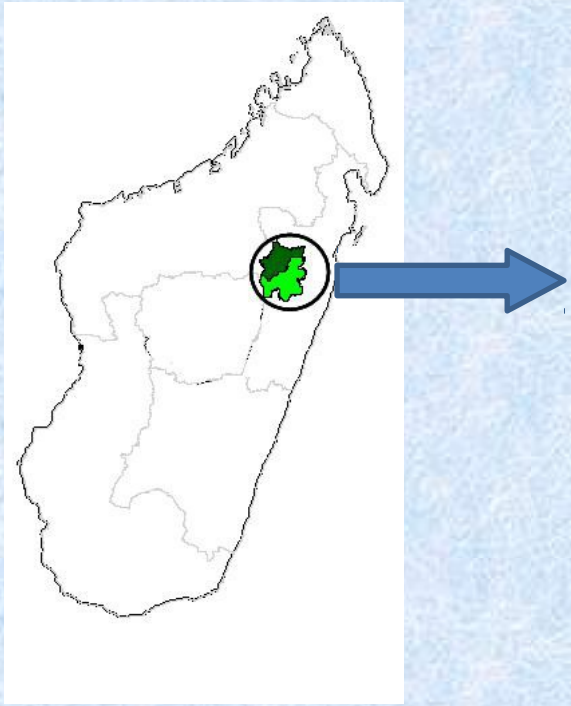
Commercial movement is the most important pathway for pathogen transmission

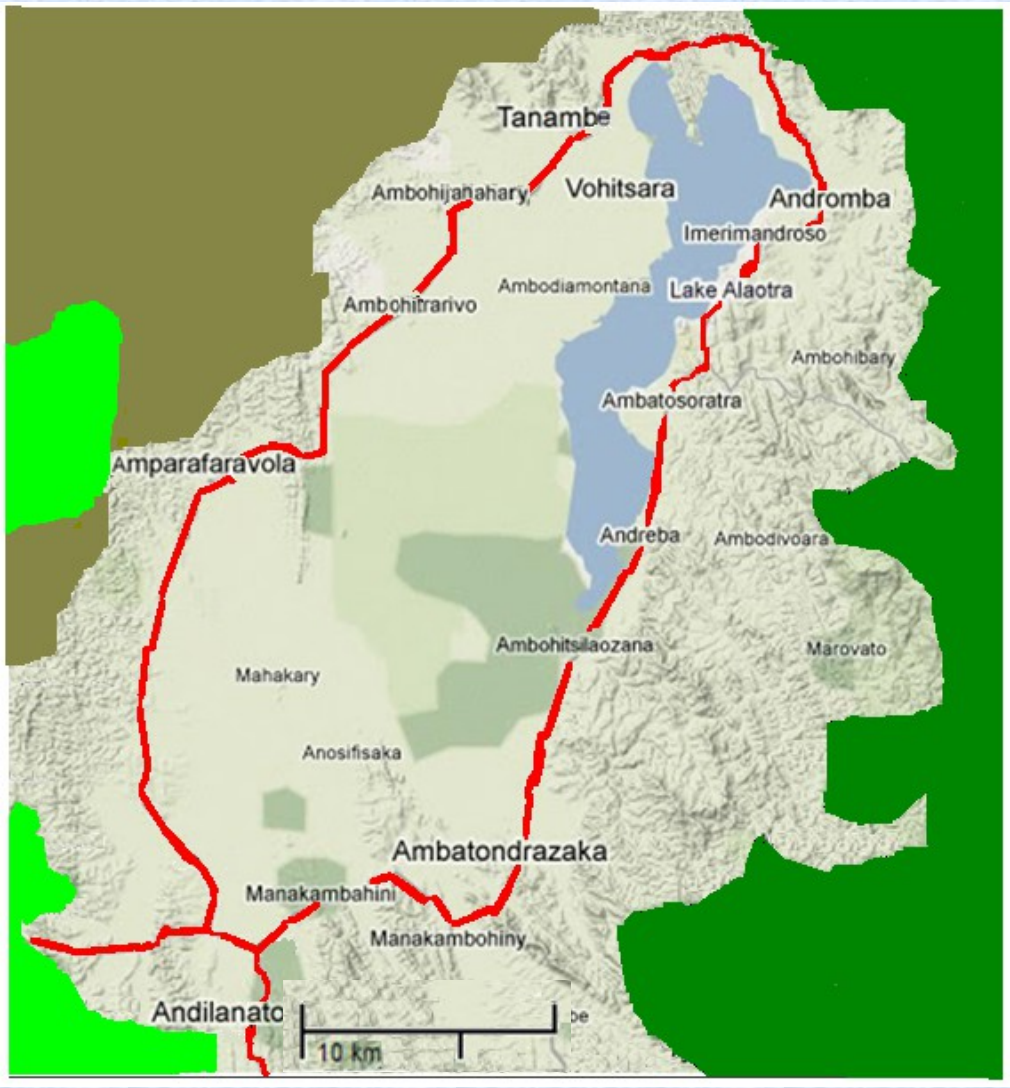
- Describe the poultry trade network
- Assess the potential role of its components and its structure in the diffusion of NCD virus and other pathogens

- Possibility to set up a targeted surveillance (less expensive)
- Possibility to test scenarios of control

Materials and methods

- Study area: **Lake Alaotra region**





- Agricultural basin (rice paddy)
- Poultry farming and trading

Materials and methods

- Network data collection
  - From December 2009 to December 2010
  - 2 types of actors in the commercial network
    - villagers (farmers) Participatory-epidemiology surveys
    - Middlemen and stallholders Cross-sectional survey
- Disease occurrence
  - Disease surveillance network
    - Field actors (CAHW, villages leaders): phone report
    - Mobile team: sampling (sera, tracheal and cloacal swabs)
    - Lab analysis: Quantitative PCR
  - Participatory surveillance
    - Report of all NCD suspicions since December 2009
    - Validation if the description corresponded with outbreak definition

Materials and methods

- Data analysis

Social network analysis

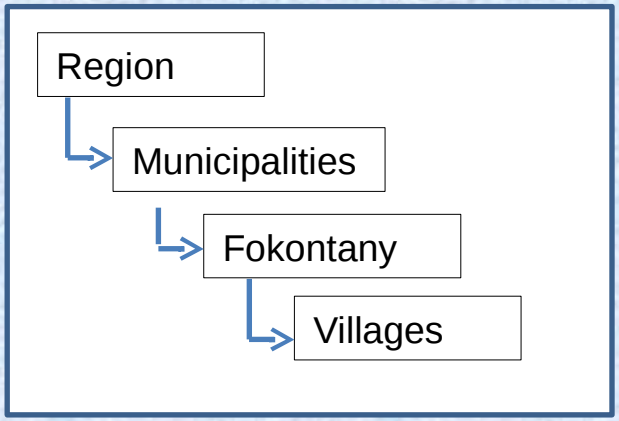
  - Definition of network elements
    - Nodes: Fokontany

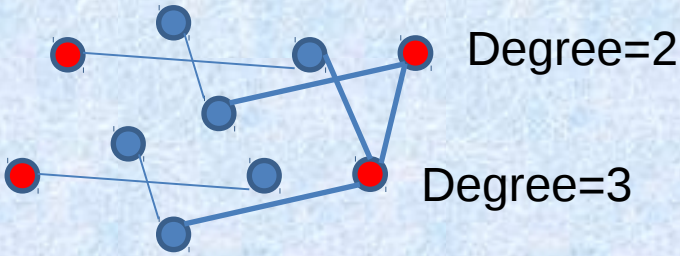
(Presence of Market Attribute of Fokontany)

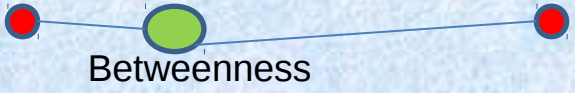
    - Ties: all birds trade which connected 2 nodes

  - Description of network (network parameters and topology)
    - Number of nodes and ties
    - Distribution of degree
    - Density
    - Centrality measures (Degree, betweenness)

Nodes= epidemiological unit





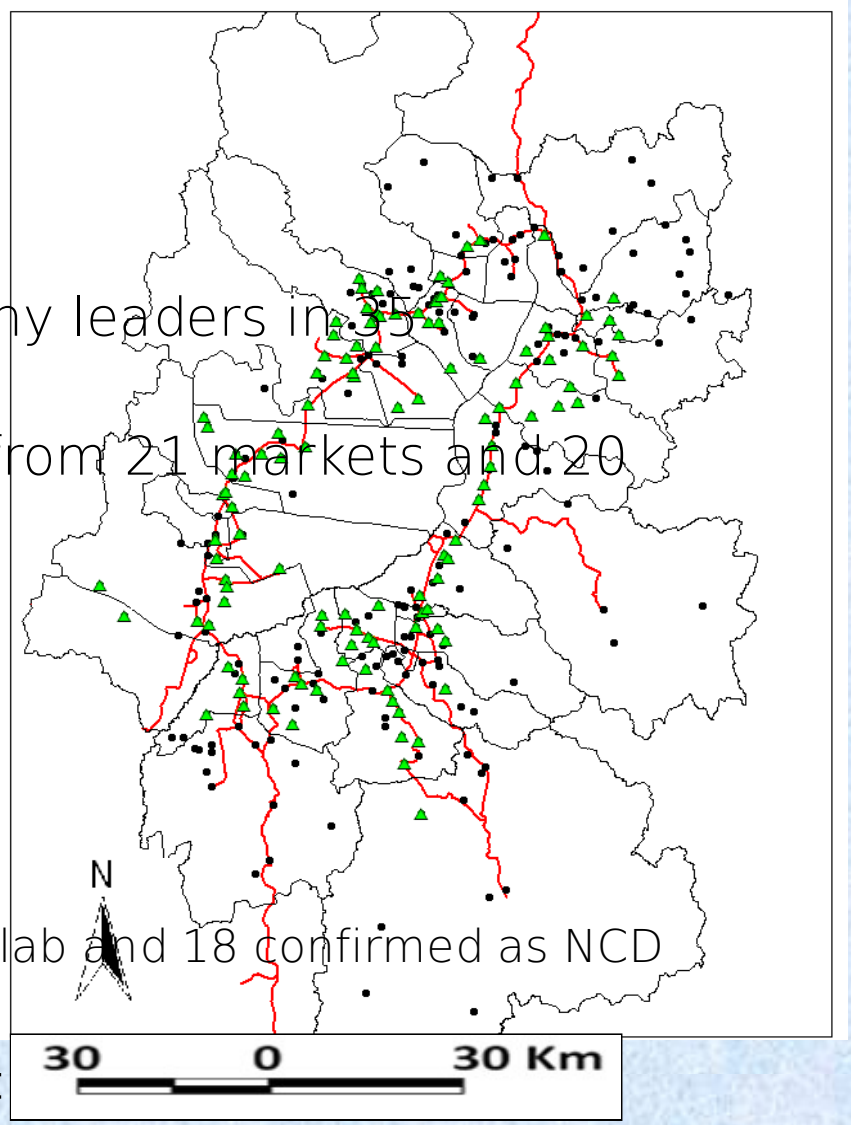


Materials and methods

- Data analysis
  - Network and disease occurrence
    - Yearly disease occurrence per Fokontany Attribute of nodes
    - Generalized linear model (Logistic Bernoulli model):
      ➔Disease occurence= f(Centrality measure)
    - Positional analysis (position within network)
      - Measure of structural equivalence with Euclidean distance
      - Partitioning: Hierarchical clustering Classes of nodes
      - Class description with intra-class values of centrality parameters and attributes
      - Comparison of number of nodes having outbreak among classes by a chi-squared test

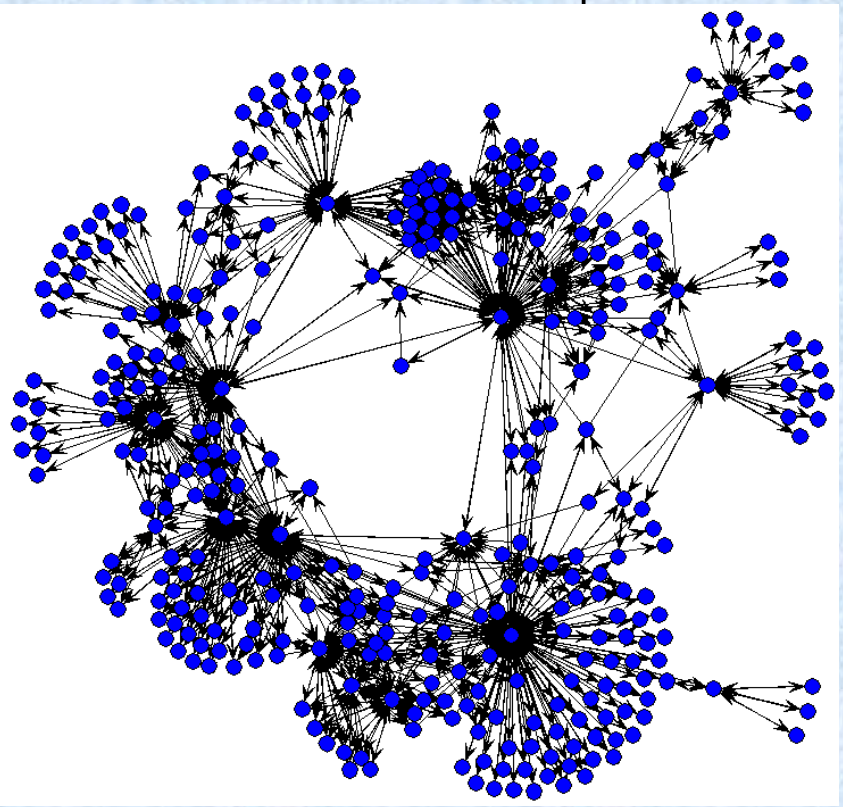
Results

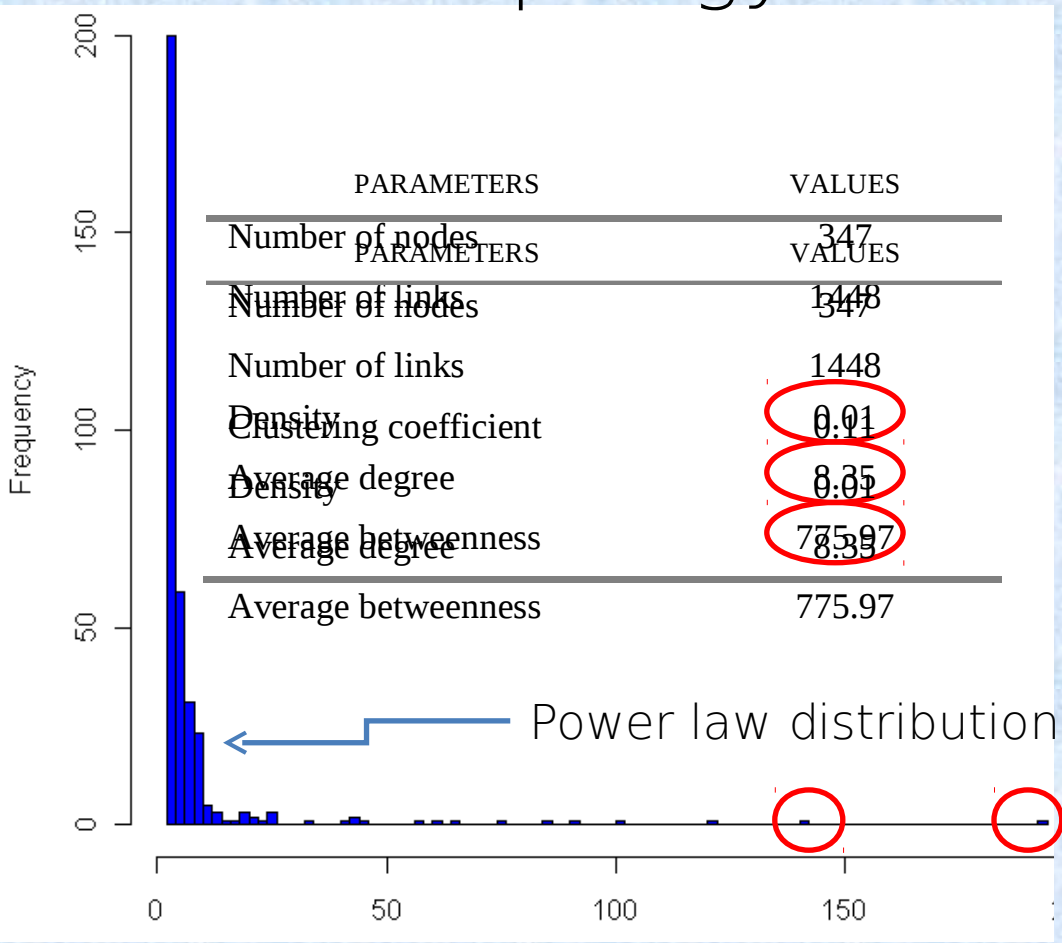
- Data collected
  - Network actors
    - 40 CAHW and all Fokontany leaders in 35 municipalities
    - 231 professional traders from 21 markets and 20 collection points
  - Diseases occurence
    - Surveillance network:
      - 35 outbreaks detected (□27 Fokontany)
      - 24 outbreaks analyzed in lab and 18 confirmed as NCD (□ 15 Fokontany /17)
    - Participatory surveillance: (□ 15 Fokontany /17)



Results

- Network parameters and topology





PARAMETERS	VALUES
Number of nodes	347
Number of links	1448
Density	0.01
Clustering coefficient	0.11
Average degree	8.35
Average betweenness	775.97

Power law distribution

- Connected directional network
- Heterogeneous

→ SCALE-FREE NETWORK

→ Favourable for disease spread (**Shirley, 2005**)

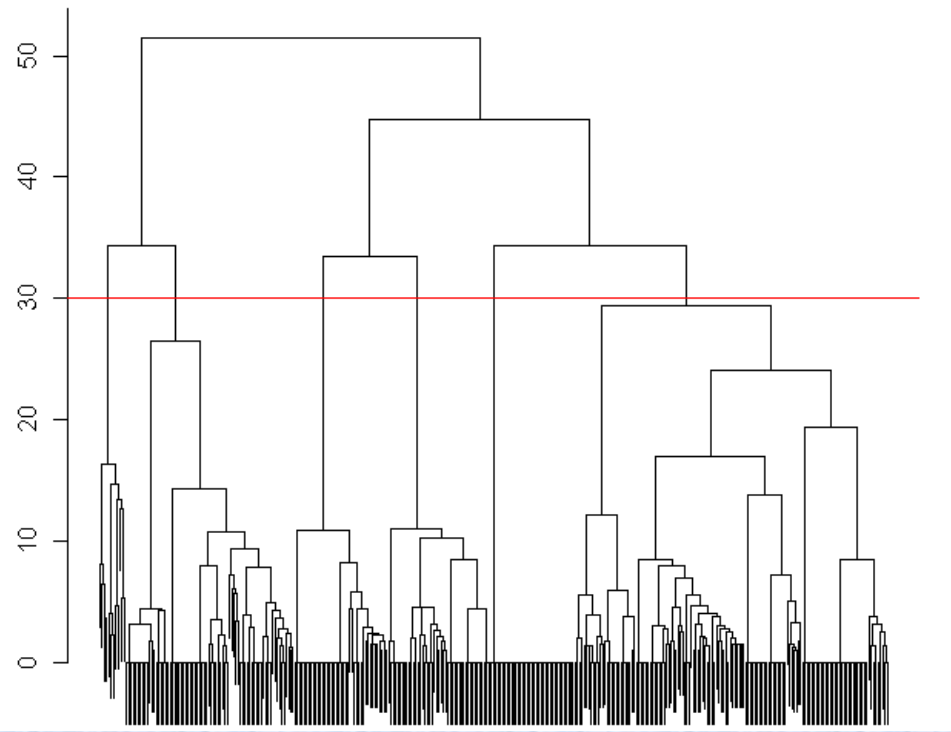
Results

- Centrality measures and disease occurrence (GLM)

PAREMETERS	COEFFICIENTS	P-VALUE
Freeman degree	0.005	0.18
Indegree	0.008	0.24
Outdegree	0.015	0.12
Betweenness	$< 10^{-4}$	0.29

Results

- Positional analysis and disease occurrence
  - Hierarchical Clustering 6 classes



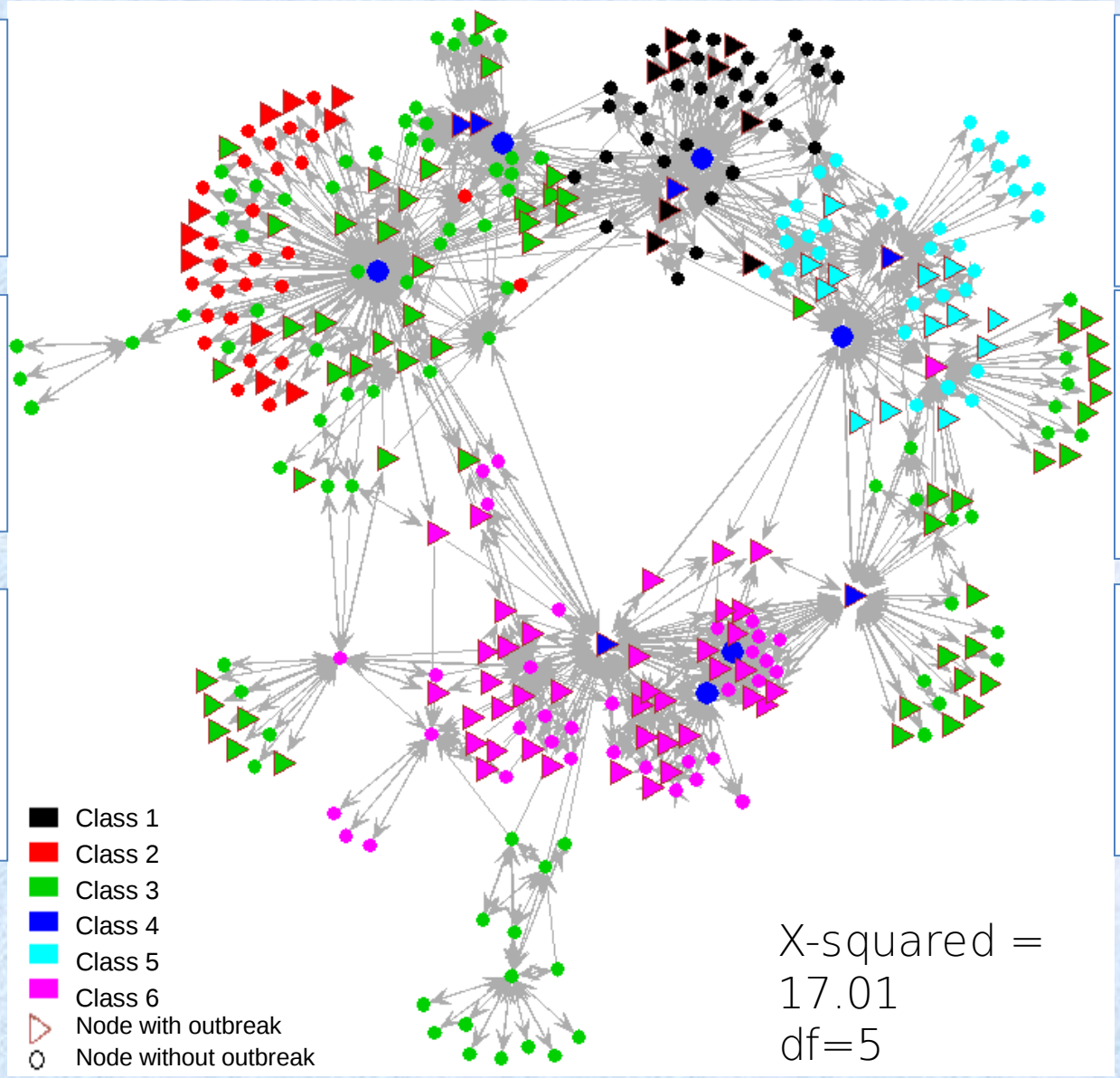
- Description of classes: illustrative variables
  - Number of nodes
  - Centrality measures: betweenness, degree
  - Attributes variables: markets, frequency of outbreaks

Results

Class 1 (n=41)
- Betweenness 55.6
- Degree 5.5
- Small market 7%
- Big market 5%
- **Outbreak: 22%**

Class 2 (n=37)
- Betweenness 0
- Degree 2.5
- Small market 5%
- Big market 0%
- **Outbreak: 27%**

Class 5 (n=45)
- Betweenness 34.4
- Degree 4.6
- Small market 7%
- Big market 0%
- **Outbreak: 29%**



Class3 (n=138)
- Betweenness 203
- Degree 5
- Small market 12%
- Big market 3%
- **Outbreak: 41%**

Class 4 (n=12)
- Betweenness 17385
- Degree 89.3
- Small market 0%
- Big market 100%
- **Outbreak: 50%**

Class 6 (n=74)
- Betweenness 389.2
- Degree 8.2
- Small market 3%
- Big market 8%
- **Outbreak: 54%**

 Association between position of nodes within the network and the occurrence of outbreak

Discussion

1.Originality

- An almost complete network together with surveillance data
- Importance of participatory approach to deal with lack of data

2.Epidemiological unit

- Fokontany *vs* village

3.Stability of network structure

- Nodes and ties remained the same although there are variation of quantity of birds and frequency of contacts within a year.

Discussion

4. Importance of Newcastle disease
   - 37% of fokontany
   - Main disease compared with fowl cholera and avian influenza

5. Sensivity and specificity of surveillance
   - Participatory surveillance: higher sensivity, unknown specificity
   - Disease surveillance: good specificity (15 / 17 Fokontany confirmed as infected by NCD)

Conclusion

- First step
  - Association between position of fokontany within network and disease occurrence
- Next step:
  - Consider the values of the links, temporality of events, virus strains (phylogenetic analysis)

  ➔model the dynamic of NCD within the network

  ➔Assess vaccination scenarios or other control measures

  ➔Set up a targeted surveillance

Acknowledgement

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Acknowledgement

Thank you for your attention!!